TOPIC 06 – KINETICS
6.2: COLLISION THEORY

IB Chemistry

T06D03

6.2 Collision theory - 3 hours

- 6.2.1 Describe the kinetic theory in terms of the movement of particles whose average energy is proportional to temperature in kelvins. (2)
- 6.2.2 Define the term activation energy, Ea. (1)
- 6.2.3 Describe the collision theory. (2)
- 6.2.4 Predict and explain, using the collision theory, the qualitative effects of particle size, temperature, concentration and pressure on the rate of a reaction. (3)
- 6.2.5 Sketch and explain qualitatively the Maxwell–Boltzmann energy distribution curve for a fixed amount of gas at different temperatures and its consequences for changes in reaction rate. (3)
- 6.2.6 Describe the effect of a catalyst on a chemical reaction. (2)
- 6.2.7 Sketch and explain Maxwell– Boltzmann curves for reactions with and without catalysts. (3)

6.2.1 – Kinetic Theory

- 6.2.1 Describe the kinetic theory in terms of the movement of particles whose average energy is proportional to temperature in kelvins. (2)
- Temperature is directly related to the kinetic energy of particles.
- The kinetic theory (often used interchangeably with the collision theory or kinetic molecular theory) assumes the following:
  - Gas is made of very small particles with non-zero mass
  - Gases constantly move in random manner
  - The # molecules in a gas is large enough for comparision
  - Gas particles spherical and perfectly elastic

6.2.1 – Assumptions for KMT

- The kinetic theory (often used interchangeably with the collision theory or kinetic molecular theory) assumes the following:
  - Gas is made of very small particles with non-zero mass
  - Gases constantly move in random manner
  - The # molecules in a gas is large enough for comparison
  - Gas particles spherical and perfectly elastic
  - Collisions with the container are perfectly elastic
  - Volume is large enough for significant space between mc's
  - Assumption that any relativistic or quantum-mechanical effects are negligible, and that any effects of the gas particles on each other are negligible, except those by collisions
  - Temperature is the only factor affecting the average KE

6.2.2 – Activation Energy

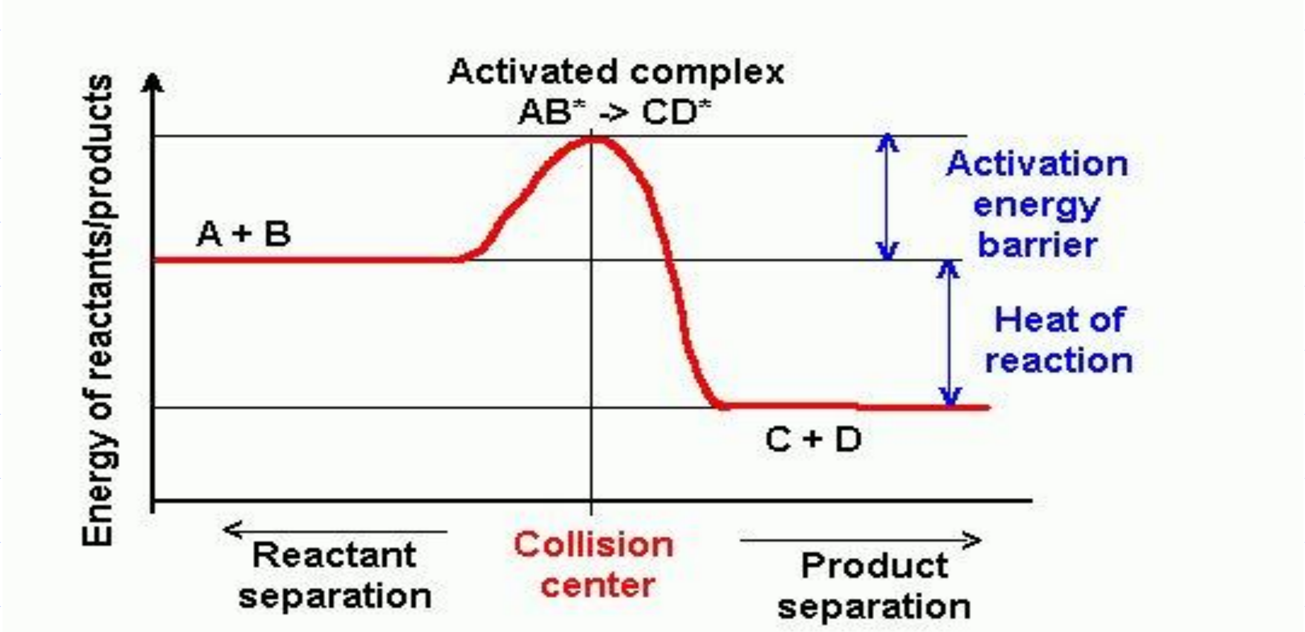
- 6.2.2 Define the term activation energy, Ea. (1)
- 6.2.3 Describe the collision theory. (2)

6.2.3 – Collision Theory

- Simple **collision theory** states that before a chemical reaction can occur, the following requirements must be met:
  - Reactants (ions, atoms, mc) must physically collide and come into direct contact with each other
  - Molecules must collide in the correct relative position so active functional groups are aligned. Overcoming **steric factors** is known as **collision geometry**.
  - Each of the particles must be traveling at sufficient velocity so that enough kinetic energy is provided when the collide for the reaction to occur. This energy barrier is known as the **activation energy**

6.2.3 – Activation Energy

- Values of activation energy, E_a, vary widely between chemical reactions and control how rapidly reactions take place.
- Most reactions involve a number of steps, so E_a best corresponds to individual elementary steps



6.2.3 – Relative E_a values

- Fast reactions are associated with low values of energy barriers (E_a)
- Slow reactions are associated with high values of energy barriers (E_a)
- If the colliding species do not possess sufficient kinetic energy to surmount the energy barrier and/or the correct collision geometry then an ineffective collision will occur and the reacting species will no undergo a chemical reaction.

6.2.4 – Effects on Rate of Reaction

- 6.2.4 Predict and explain, using the collision theory, the qualitative effects of particle size, temperature, concentration and pressure on the rate of a reaction. (3)

6.2.4 – Effect of Concentration

- The concentration describes the numbers of particles (usually ions in solution) in a particular volume of solution
  - ____________
- It's *generally* found that the greater the [C] of reactants, the greater the reaction rate
  - Due to increasing collisions as there are more to collide
  - *Generally* doubling the [C], doubles the rate
  - Explains why the greatest reaction rates are as soon as reactants are mixed = higher [C]

6.2.4 – Effect of Pressure

- When one or more of the reactants are gases, the pressure can lead to an increase in rate of reaction
- Increased pressure forces the molecules together for more collisions
- An increase in pressure for a gas is regarded as an increase in 'concentration' since more gas molecules are present in a particular volume of space
- Liquids and solids are affected very little by changes in pressure

6.2.4 – Effect of Temperature

- When the temperature of any particle (regardless of state of matter) is increased, it moves faster.
- This has two consequences:
  - Particles travel greater distance in a given time and so will be involved in more collisions
  - More importantly, at higher T's a larger proportion of the colliding species will have kinetic energies equal to or exceeding the energy barrier
  - Often, a rise of 10^{o}C doubles the reaction rate
    - This does not hold true for all reactions

6.2.4 – Effect of Particle Size

- When one of the reactants is a solid, the reaction takes place on the surface of the solid
- If the solid is broken up into smaller pieces or particles, the surface area is increased, giving a greater area for collisions to occur
- Several important industrial catalysts are solids and the reactions occur on the surface of the catalyst

6.2.4 – Effect of Light

- Many particles are light sensitive and increase in reaction rate when exposed to light (often UV)
- Silver halides, silver nitrate, hydrogen peroxide, and nitric acid are all **photosensitive** and undergo partial decomposition (to form radicals•) in the presence of sunlight
  - What's a radical? A radical (ex. NO•) is an unpaired electron which is therefore fairly reactive (you will see in Organic and Environmental Chemistry)
  - This is why hydrogen peroxide is stored in a dark brown bottle to keep the light out!

6.2.5 – 6.2.7

Next class we will discuss the Maxwell-Boltzman, curves associated with M-B, and the effects of catalysts

6.2.5 – Maxwell-Boltzmann Curve

- 6.2.5 Sketch and explain qualitatively the Maxwell–Boltzmann energy distribution curve for a fixed amount of gas at different temperatures and its consequences for changes in reaction rate. (3)

6.2.6 – Effect of Catalysts

- 6.2.6 Describe the effect of a catalyst on a chemical reaction. (2)

6.2.7 – Maxwell-Boltzman

- 6.2.7 Sketch and explain Maxwell–Boltzmann curves for reactions with and without catalysts. (3)